U.S. Naval Air Development Center

Johnsville, Pennsylvania

REPORT NO. NADC-AE-6607 21 MAR 1966

PHASE I
FEASIBILITY STUDY ON USE OF CRIMP TERMINALS AS JUNCTIONS IN PLACE OF SOLDERED OR WELDED JUNCTIONS FOR THERMOCOUPLE WIRES

FINAL REPORT
WEPTASK NO. RAE50J011/2021/F012-07-01
Problem No. 45AE53-28

Each transmittal of this document outside the agencies of the U.S. Government must have prior approval of Commanding Officer, U.S. Naval Air Development Center.

NOTICES

1. **PRODUCT ENDORSEMENT** - The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or rights to use such products.

DEPARTMENT OF THE NAVY
U. S. NAVAL AIR DEVELOPMENT CENTER
JOHNSVILLE
WARMINSTER, PA. 18974

Aero-Electronic Technology Department

REPORT NO. NADC-AE-6607 21 March 1966

PHASE I
FEASIBILITY STUDY ON USE OF CRIMP TERMINALS AS JUNCTIONS IN PLACE OF SOLDERED OR WELDED JUNCTIONS FOR THERMOCOUPLE WIRES

FINAL REPORT
WEPTASK NO. RAE50J011/2021/F012-07-01
Problem No. J45AE53-28

A feasibility study was performed to determine the use of crimp-type terminals to form the junction of thermocouple wires in place of the presently used silver soldered or welded junctions. The study revealed that crimp-type terminals made of metal compatible with the thermocouple wires can be used successfully to form the junction of the wires, and are easily installed with the proper crimping tools.

Reported by: J. W. Gordon
J. W. Gordon
Electrical Division

Approved by: L. M. Cobb
L. Cobb, Superintendent
Electrical Division

D. W. Mackiernan
Technical Director

S U M M A R Y

INTRODUCTION

WEPTASK No. RAE50J011/2021/F012-07-01, Problem No. J45AE53-28 was established by reference (a) for the development of crimp-type terminals and associated tools for thermocouple wire junctions, and the preparation of a specification and military standards covering the developed items.

NAVAIRDEVCEN performed a feasibility study on the use of crimp terminals as junctions for thermocouple wires.

CONCLUSIONS

The study revealed that crimp-type terminals made of a metal that is compatible with the thermocouple wires can be used to form the junction of the wires.

Copper terminals, such as Standard No. MS20659B(ASG) and Standard No. MS25036D(ASG) are not compatible with the thermocouple wires for use as a means of forming thermocouple junctions.

B A C K G R O U N D

The current practice for establishing the junction of thermocouple wires for use in aircraft is by silver soldering or welding; however this practice was found difficult to accomplish and time consuming. After consultation with the BUWEPS cognizant engineer, it was decided that the first phase of the project should be devoted to determining the feasibility of forming the junction of the wires by the use of crimp-type terminals. Reference (a) requested that thermocouple wires complying with Specifications No. MIL-W-5845B, reference (b), MIL-W-5846C, reference (c), and MIL-W-5908C, reference (d), be used in the investigation. Because of the large variety and numbers of thermocouple wires covered by Specifications No. MIL-W-5845B, MIL-W-5846C, and MIL-W-5908C, the feasibility study was restricted to the wires identified in table I.

M A T E R I A L A N D I N S T R U M E N T A T I O N I D E N T I F I C A T I O N

The thermocouple wires were manufactured by Lewis Engineering Company, Naugatuck, Connecticut. The terminals and both crimping tools were manufactured by Thomas and Betts Company, Elizabeth, New Jersey. The furnace used during the laboratory tests was identified as "Thermocouple Furnace," catalog No. 9003-S, manufactured by Leeds and Northrup Company. A certified Leeds and Northrup pure platinum - platinum +10 percent rhodium thermocouple was used as a control reference during all tests performed in the temperature range +20° to +1000° C. A special copper-constantan thermocouple, catalog No. 8693-067-168, was used as a control reference for all tests performed in the temperature range -70° to +20° C. A Leeds and Northrup model No. 8662 potentiometer with a range 0 to 80.5 millivolts was used to measure the output in millivolts from the thermocouple test samples and the control references.

I N V E S T I G A T I O N

Early in the investigation it became apparent that standard tin plated copper terminals, such as those covered by Standards No. MS20659B(ASG) and MS25036D(ASG), references (e) and (f), could not be used as the terminating junction of the thermocouple wires. This junction generated a spurious voltage, particularly during and after the junction was exposed to moisture or salt fog. It is believed that the intimate contact of the dissimilar metals of the terminal versus the thermocouple wires established a galvanic action that resulted in the spurious voltage.

To correct the above situation, crimp-type terminals with the same general configurations and dimensions as the Standard No. MS20659B(ASG) terminals, but made of Chromel and of Constantan were procured from Thomas and Betts Company. The Chromel terminals were used as the junction of the Chromel-Alumel wires and the Constantan terminals as the junction of the Iron-Constantan and Copper-Constantan wires. Since the two wires forming the thermocouple were crimped in one terminal, an over size terminal was used when considered necessary (see tables II, III, and IV).

Thirteen thermocouple samples per Item Number, for a total of 78 samples, were prepared as shown in table V (see table I for identification of Item Number). The welded junction of the thermocouple wires was included in the program as a means of comparison. The performance of the welded junction was similar to that of a silver-solder junction.

The junction termination of thermocouple samples 1 through 5 of each item identified in table I were exposed to the temperature range specified in Specifications No. MIL-W-5845B, MIL-W-5846C, and MIL-W-5908C, as applicable. Millivolt readings were recorded for temperatures in increments of 50° or 100° C over the applicable temperature range. The millivolt readings were recorded when temperature stabilization was reached as indicated by the control reference thermocouples mentioned under "Material and Instrumentation Identification."

Samples 1 through 5 were then subjected to a vibration test complying with Specification No. MIL-T-7928E(ASG), reference (g), followed by a temperature calibration reading. The same terminals were then exposed to a salt fog corrosion test complying with Specification No. MIL-T-7928E(ASG), followed by a temperature calibration reading.

Samples 6 through 13 were also subjected to the above-mentioned vibration test. Following this, samples 6, 7, 10, and 11 were exposed for 6 hours to the maximum specified temperature for each item, i.e., samples of items A and B to 500° C, items C and D to 1000° C, and items E and F to 400° C. Samples 8, 9, 12, and 13 were subjected to 0° C for 6 hours. Samples 6 through 13 were then subjected to a tensile test. Results are shown in tables II, III, and IV. During the tensile test, the two wires were held in the movable head of the tensile machine while the terminal was held in the fixed head.

Recorded millivolt readings versus temperatures were plotted for all thermocouple junctions. These were then compared with plotted curves of the millivolt temperature readings specified in Specifications No. MIL-W-5845B, MIL-W-5846C, and MIL-W-5908C. The graphs are not included in this report, because of their large number, but they are available for future reference at NAVAIRDEVCEN.

RESULTS

Analysis of the graphs revealed that recorded millivolt-temperature values deviated only slightly from specified values, and were well within the tolerances specified by Specifications No. MIL-W-5845B, MIL-W-5846C, and MIL-W-5908C. The curves also indicated that no discernible difference was apparent between millivolt values obtained on welded thermocouple junctions and crimped terminal thermocouple junctions. Basically, the same values were measured on terminals crimped with the WT-131 tool or the Standard No. MS17776-1(WEP), reference (h), tool.

No degradations in the millivolt readings were noted as a result of the samples being exposed to salt fog and to vibration.

Analysis of the tensile test measurements indicated that the crimping tools provided a secure termination of the wires in the terminals.

During the 6-hour high temperature test it was found that the insulation on the chromel-alumel wires, rated for temperatures up to 1000° C by their specification, burned off. To overcome this deficiency during the tests, that portion of the individual wires actually exposed to the high temperatures was encased in porcelain sleeves.

This feasibility study has demonstrated that crimp-type terminals made of a metal that is compatible with the thermocouple wires may be used satisfactorily to form the thermocouple junction of the wires.

Either a Standard No. MS17776-1(WEP) tool or a Thomas and Betts WT-131 Tool may be used to crimp the special terminals.

Thomas and Betts Company is the only manufacturer at present that has a line of crimp-type thermocouple terminals. However, other terminal manufacturers have stated that they would produce such terminals if the market demand was large enough to make it feasible economically.

REFERENCES

(a) BUAER ltr Aer-AE-823/20, 26 Mar 1959.
(b) Spec No. MIL-W-5845B; Wire, Electrical, Iron and Constantan, Thermocouple.
(c) Spec No. MIL-W-5846C; Wire, Electrical Chromel and/or Alumel, Thermocouple.
(d) Spec No. MIL-W-5908C; Wire, Electrical, Copper and Constantan, Thermocouple.
(e) Std No. MS20659B(ASG); Terminal, Lug, Crimp Style, Copper, Uninsulated Class 1.
(f) Std No. MS25036D(ASG); Terminal, Lug, Crimp Style, Copper, Insulated, Class 1.
(g) Spec No. MIL-T-7928E(ASG); Terminals: Lug and Splice, Crimp-Style, Copper.
(h) Std No. MS17776-1(WEP); Crimping Tool - Electric Wire Terminal, Hand, 22-10 Capacity.

TABLE I

IDENTIFICATION OF THERMOCOUPLE WIRES

Item No.	Spec No.	Nomenclature	Type No.	Class	Wire Size	Conductor Construction	Temp Range (° C)
A	MIL-W-5845B	Iron-Constantan	I	J	18	Stranded	-70 to 500
B	MIL-W-5845B	Iron-Constantan	I	H	18	Solid	-70 to 500
C	MIL-W-5846C	Chromel-Alumel	I	E	20	Stranded	0 to 1000
D	MIL-W-5846C	Chromel-Alumel	I	C	18	Solid	0 to 1000
E	MIL-W-5908C	Copper-Constantan	I	E	18	Stranded	-70 to 400
F	MIL-W-5908C	Copper-Constantan	I	C	18	Solid	-70 to 400

NOTE: All wires were insulated duplex.

TABLE II

RESULTS OF TENSILE TESTS ON TERMINAL JUNCTIONS
USING SPECIFICATION NO. MIL-W-5845B WIRE

Wire			Terminal		Crimping	Temp	Tensile (lb)	
Type	Class	Size	Metal	Size	Tool	(° C)	Recorded	Spec*
I	J	18	Constantan	16-14	A**	0	89.8	38.0
I	H	18	Constantan	16-14	A	0	32.0	38.0
I	J	18	Constantan	16-14	B***	0	59.6	38.0
I	H	18	Constantan	16-14	B	0	71.4	38.0
I	J	18	Constantan	16-14	A	500	63.7	38.0
I	H	18	Constantan	16-14	A	500	97.8	38.0
I	J	18	Constantan	16-14	B	500	101.0	38.0
I	H	18	Constantan	16-14	B	500	88 2	38.0

TABLE III

RESULTS OF TENSILE TESTS ON TERMINAL JUNCTIONS
USING SPECIFICATION NO. MIL-W-5908C WIRE

Wire			Terminal		Crimping	Temp	Tensile (lb)	
Type	Class	Size	Metal	Size	Tool	(° C)	Recorded	Spec*
I	E	18	Constantan	16-14	A**	0	86.0	38.0
I	E	18	Constantan	16-14	B***	0	82.8	38.0
I	C	18	Constantan	16-14	B	0	81.6	38.0
I	C	18	Constantan	16-14	A	0	59.6	38.0
I	C	18	Constantan	16-14	A	400	51.6	38.0
I	C	18	Constantan	16-14	B	400	56.3	38.0
I	E	18	Constantan	16-14	A	400	56.1	38.0
I	E	18	Constantan	16-14	B	400	39.2	38.0

NOTES: * From Specification No. MIL-T-7928E. Used for reference only.
** A = Standard No. MS17776-1 tool.
*** B = WT-131 tool.

TABLE IV

RESULTS OF TENSILE TESTS ON TERMINAL JUNCTIONS
USING SPECIFICATION NO. MIL-W-5846B WIRE

Wire			Terminal		Crimping	Temp	Tensile (lb)	
Type	Class	Size	Metal	Size	Tool	(° C)	Recorded	Spec*
I	E	20	Chromel	22-18	A**	0	38.6	19
I	E	20	Chromel	22-18	B***	0	125.1	19
I	E	20	Chromel	22-18	A	1000	70.0	19
I	E	20	Chromel	22-18	B	1000	77.2	19
I	C	18	Chromel	16-14	A	0	48.2	19
I	C	18	Chromel	16-14	B	0	163.3	19
I	C	18	Chromel	16-14	B	1000	95.5	19
I	C	18	Chromel	16-14	A	1000	87.7	19

NOTES: * From Specification No. MIL-T-7928E. Used for reference only.
** A = Standard No. MS17776-1 tool.
*** B = WT-131 tool.

TABLE V

THERMOCOUPLE SAMPLE IDENTIFICATION

Item No.	Sample No.	Type of Junction	Crimping Tool	
			WT-131	Std No. MS17776-1
A & B	1,6,7,8,9	Constantan Terminal	X	-
	2,3,4,10,11,12,13	Constantan Terminal	-	X
	5	Wires Welded	-	-
C & D	1,6,7,8,9	Chromel Terminal	X	-
	2,3,4,10,11,12,13	Chromel Terminal	-	X
	5	Wires Welded	-	-
E & F	1,6,7,8,9	Constantan Terminal	X	-
	2,3,4,10,11,12,13	Constantan Terminal	-	X
	5	Wires Welded	-	-

Naval Air Development Center, Johnsville, Pa.
Aero-Electronic Technology Department
(Report No. NADC-AE-6607)
PHASE I FEASIBILITY STUDY ON USE OF CRIMP TERMINALS AS JUNCTIONS IN PLACE OF SOLDERED OR WELDED JUNCTIONS FOR THERMOCOUPLE WIRES, by J. W. Gordon. 21 Mar 1966. 10 p. Final Report.
UNCLASSIFIED
Includes references.
A FEASIBILITY STUDY WAS PERFORMED TO DETERMINE THE USE OF CRIMP-TYPE TERMINALS TO FORM THE JUNCTION OF THE THERMOCOUPLE WIRES IN PLACE OF THE

1. Electrical
2. Terminals
3. Crimp
4. Feasibility Study
I. Gordon, J. W.

WEPTASK RAE50J011/2021/F012-07-01, Problem No. J45AE53-28

UNCLASSIFIED

Naval Air Development Center, Johnsville, Pa.
Aero-Electronic Technology Department
(Report No. NADC-AE-6607)
PHASE I FEASIBILITY STUDY ON USE OF CRIMP TERMINALS AS JUNCTIONS IN PLACE OF SOLDERED OR WELDED JUNCTIONS FOR THERMOCOUPLE WIRES, by J. W. Gordon. 21 Mar 1966. 10 p. Final Report.
UNCLASSIFIED
Includes references.
A FEASIBILITY STUDY WAS PERFORMED TO DETERMINE THE USE OF CRIMP-TYPE TERMINALS TO FORM THE JUNCTION OF THE THERMOCOUPLE WIRES IN PLACE OF THE

1. Electrical
2. Terminals
3. Crimp
4. Feasibility Study
I. Gordon, J. W.

WEPTASK RAE50J011/2021/F012-07-01, Problem No. J45AE53-28

UNCLASSIFIED

Naval Air Development Center, Johnsville, Pa.
Aero-Electronic Technology Department
(Report No. NADC-AE-6607)
PHASE I FEASIBILITY STUDY ON USE OF CRIMP TERMINALS AS JUNCTIONS IN PLACE OF SOLDERED OR WELDED JUNCTIONS FOR THERMOCOUPLE WIRES, by J. W. Gordon. 21 Mar 1966. 10 p. Final Report.
UNCLASSIFIED
Includes references.
A FEASIBILITY STUDY WAS PERFORMED TO DETERMINE THE USE OF CRIMP-TYPE TERMINALS TO FORM THE JUNCTION OF THE THERMOCOUPLE WIRES IN PLACE OF THE

1. Electrical
2. Terminals
3. Crimp
4. Feasibility Study
I. Gordon, J. W.

WEPTASK RAE50J011/2021/F012-07-01, Problem No. J45AE53-28

UNCLASSIFIED

Naval Air Development Center, Johnsville, Pa.
Aero-Electronic Technology Department
(Report No. NADC-AE-6607)
PHASE I FEASIBILITY STUDY ON USE OF CRIMP TERMINALS AS JUNCTIONS IN PLACE OF SOLDERED OR WELDED JUNCTIONS FOR THERMOCOUPLE WIRES, by J. W. Gordon. 21 Mar 1966. 10 p. Final Report.
UNCLASSIFIED
Includes references.
A FEASIBILITY STUDY WAS PERFORMED TO DETERMINE THE USE OF CRIMP-TYPE TERMINALS TO FORM THE JUNCTION OF THE THERMOCOUPLE WIRES IN PLACE OF THE

1. Electrical
2. Terminals
3. Crimp
4. Feasibility Study
I. Gordon, J. W.

WEPTASK RAE50J011/2021/F012-07-01, Problem No. J45AE53-28

UNCLASSIFIED

PRESENTLY USED SILVER SOLDERED OR WELDED JUNC-
TIONS. THE STUDY REVEALED THAT CRIMP-TYPE
TERMINALS MADE OF METAL COMPATIBLE WITH THE
THERMOCOUPLE WIRES CAN BE USED SUCCESSFULLY TO
FORM THE JUNCTION OF THE WIRES, AND ARE EASILY
INSTALLED WITH THE PROPER CRIMPING TOOLS.
UNCLASSIFIED

UNCLASSIFIED

PRESENTLY USED SILVER SOLDERED OR WELDED JUNC-
TIONS. THE STUDY REVEALED THAT CRIMP-TYPE
TERMINALS MADE OF METAL COMPATIBLE WITH THE
THERMOCOUPLE WIRES CAN BE USED SUCCESSFULLY TO
FORM THE JUNCTION OF THE WIRES, AND ARE EASILY
INSTALLED WITH THE PROPER CRIMPING TOOLS.
UNCLASSIFIED

UNCLASSIFIED

PRESENTLY USED SILVER SOLDERED OR WELDED JUNC-
TIONS. THE STUDY REVEALED THAT CRIMP-TYPE
TERMINALS MADE OF METAL COMPATIBLE WITH THE
THERMOCOUPLE WIRES CAN BE USED SUCCESSFULLY TO
FORM THE JUNCTION OF THE WIRES, AND ARE EASILY
INSTALLED WITH THE PROPER CRIMPING TOOLS.
UNCLASSIFIED

UNCLASSIFIED

DOCUMENT RELEASE STATUS
NAVWEPS FORM 2000/8 (REV. 2-64)

THIS PAPER IS CHEMICALLY TREATED. NO CARBON PAPER IS REQUIRED

AD NUMBER (To be inserted by DDC) **480221**

CLASSIFICATION

UNCLASSIFIED

UNCLASSIFIED WHEN ENCLOSURE IS REMOVED

ORIGINATING AGENCY: Naval Air Development Center, Johnsville, Warminster, Pennsylvania

ENCLOSURE (REPORT TITLE): Phase I, Feasibility Study on Use of Crimp Terminals as Junctions in Place of Soldered or Welded Junctions for Thermocouple Wires - 6 copies

REPORT SERIES AND NUMBER: NADC-AE-6607

REPORT DATE: 21 March 1966

COG. BUWEPS CODE (For use in BUWEPS only)

CONTRACT/PROJECT/WEPTASK NUMBER: RAE50J011/2021/F012-07-01
Problem No. J45AE53-28

SECURITY CLASSIFICATION	UNCLAS.	CONFI.	SECRET
REPORT	X		
TITLE OR SUBJECT	X		
ABSTRACT OR SUMMARY	X		

TO Administrator
Defense Documentation Center for Scientific and Technical Information (DDC)
Bldg. #5, Cameron Station
Alexandria, Virginia 22314

Enclosure is forwarded for distribution subject to limitations checked below. Request AD number be inserted in space above, one copy of this letter be returned to originating activity if shown below; and two copies be sent to Chief, Bureau of Naval Weapons.

Qualified requesters may obtain copies of this report direct from DDC.	U.S. Government Agencies may obtain copies of this report direct from DDC. Other qualified DDC users should request through no source. (Not available to non-Government DDC users.)
Qualified requesters may obtain copies of this report direct from DDC. Foreign announcement and dissemination of this report by DDC is not authorized.	U.S. Military Agencies may obtain copies of this report direct from DDC. Other qualified DDC users should request through no source. (Not available to non-military DDC users.)
U.S. Government Agencies may obtain copies of this report direct from DDC. Other qualified DDC users should request through the Chief, Bureau of Naval Weapons, Washington, D.C. 20360.	All distribution of this report is controlled. Qualified DDC users should request through the Chief, Bureau of Naval Weapons, Washington, D.C. 20360.
U.S. Military Agencies may obtain copies of this report direct from DDC. Other qualified DDC users should request through the Chief, Bureau of Naval Weapons, Washington, D.C. 20360.	

Commanding Officer (AEHP)
U.S. Naval Air Development Center
Johnsville, Warminster,
Pennsylvania 18974

Each transmittal of this document outside the agencies of the U.S. Government must have prior approval of Commanding Officer, U.S. Naval Air Development Center.

SIGNATURE: E Ross Mullen

TITLE: E. ROSS MULLEN
FY DIRECTION

Chief, Bureau of Naval Weapons (DLI-302)
Navy Department
Washington, D.C. 20360

CODE: AEHP/35

DATE: 12 APR 1966

CLASSIFICATION

UNCLASSIFIED

UNCLASSIFIED WHEN ENCLOSURE IS REMOVED